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S. Edmund BERGER, residing at 298 Grayton Road, Tonawanda, NY, 14150, declares:

(1) that he knows both the German and English languages well;

(2) that he translated the German document entitled "Assembly Bearing with Hydraulic Damping" from German to English;

(3) that the attached English Translation is a true and correct translation of the above-identified German document to the best of his knowledge and belief; and

(4) that all statements made of his knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

Dated: October 24, 2004

Signed: ______________________
S. Edmund BERGER

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(54) Title: **ASSEMBLY BEARING WITH HYDRAULIC DAMPING**

Abstract: The invention relates to an assembly bearing with hydraulic damping, especially for supporting engines and/or gearboxes in motor vehicles. Said bearing comprises a working chamber (10) and a compensation chamber (20) which respectively have partially elastically deformable walls (30, 40) and are separated by a dividing wall (50), but interconnected by means of a damping channel (60) through which a fluid is guided, in addition to another passage opening (14) which can be variably adjusted from outside. According to the invention, a decoupling device for insulating high-frequency, low-

amplitude vibrations is provided in the dividing wall (50), the other passage opening (14) being arranged upstream or downstream of said decoupling device.

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Title

Assembly Bearing with Hydraulic Damping

Description

Technical Field

The invention relates to an assembly bearing with hydraulic damping, especially for supporting engines and/or gearboxes in motor vehicles, with a working chamber and a compensation chamber which respectively have partially elastically deformable walls and are separated from one another by a dividing wall, but are interconnected by means of a damping channel through which a fluid is guided, in addition to another passage opening that can be variably adjusted from outside.

Prior Art

Hydraulically damped assembly bearings are generally known and frequently described in the literature. An assembly bearing of the afore-indicated kind is known from DE 39 33 252 C2. In essence, the known assembly bearing is provided with a hydraulic chamber divided by a dividing wall into a working chamber and a compensation chamber. In the dividing wall is disposed a damping channel which interconnects the two chambers and permits a fluid to flow through. The working chamber is limited at the top by a spring body essentially having the shape of a truncated cone and made of an elastic rubber material with a vulcanized-on connecting piece with fastening means. The working chamber is limited at the bottom by a compensation membrane capable of taking up volume without pressure and which is covered by a bearing cap also provided with fastening means. In addition, an overflow gap is provided in the compensation chamber the opening cross-section of which can be variably adjusted from outside. The opening gap is formed by an axially displaceable, conical lowering plate in the compensation chamber and provided with breaches and by a corresponding conical counter-surface which is fitted to an intermediate part.

In this manner, a quenching effect variable in frequency is achieved, said effect being intended to result in a frequency-dependent, regulatable acoustic abatement.

The known assembly bearing has the drawback that, because of the inertia of the liquid column in the damping channel compared to the higher-frequency and high-frequency low-amplitude excitation, these vibrations are not transmitted to the compensation chamber. As a result, the desired quenching does not take effect or takes effect only insufficiently.

Representation of the Invention

The object of the invention is to further develop an assembly bearing of the described kind so that, in particular, it can decouple or dampen higher-frequency and high-frequency vibrations of small amplitudes such as those generated on the drive unit of, in particular, vehicles with higher rotational speeds and faster-traveling vehicles. In addition, it should be possible to provide an idle mode by simple additional fabrication measures. This objective is reached by means of an assembly bearing with hydraulic damping having all features of Claim 1. Advantageous embodiments of the invention are described in the subclaims.

According to the invention, in an assembly bearing with hydraulic damping, particularly for supporting engines and/or gearboxes, in motor vehicles, with a working chamber and a compensation chamber which respectively have partially elastically deformable walls and are separated from one another by a dividing wall, but are interconnected by means of a damping channel through which a fluid is guided, and with an additional passage opening that can be variably adjusted from outside, the dividing wall comprises a decoupling device for isolating high-frequency, low-amplitude vibrations. According to the invention, said decoupling device is disposed either upstream or downstream of the additional passage opening.

The springing characteristics of the assembly bearing of the invention with hydraulic damping are determined, as in conventionally decoupled hydraulic anti-vibration mountings, by four main components: the bearing spring, the expanding spring, the quenching channel and the decoupling device for acoustic vibrations. Thus, the assembly bearing of the invention combines in itself all advantages of a conventionally decoupled hydraulic anti-vibration mounting, for example:

1. Vibration decoupling: The bearing spring is soft, and the decoupling action is very good in the entire frequency range.

2. Quenching of the spluttering movement: In the case of very large amplitudes (spluttering movement of the assembly), the bearing must at this frequency become very stiff. To this end, the expanding spring is operated in parallel with the bearing spring. In the case of

hydraulic anti-vibration mountings, this occurs through the action of the fluid mass in the damping channel, this mass being adjusted so that, like a quencher, it vibrates counter to the excitation.

3. Decoupling of the acoustics: The decoupling device comes into play at high frequencies (low amplitudes, structure-borne noise). Said device absorbs the low-amplitude, high-frequency vibrations and isolates them from the undercarriage.

Moreover, as a result of the additional passage opening, the assembly bearing of the invention has an additional quenching function which can be flexibly adapted as well as actively controlled. In contrast to the known actively controllable hydraulic anti-vibration mountings, however, the assembly bearing of the invention is characterized by a substantially more simple construction and thus a lower fabrication cost.

In a preferred embodiment of the invention, the additional passage opening is located in the working chamber and is thus disposed upstream of the decoupling device. The advantage of this arrangement is that the inertia effect of the liquid is spatially directly coordinated with the resilience of the expanding spring which results in a better quenching action.

In another advantageous embodiment of the invention, the decoupling device comprises a membrane that in itself is known. Arrangements with a membrane are known per se. As a rule, a membrane is inserted into a membrane cage, the membrane being slack all around and particularly in the axial direction of the bearing. The slack is of a magnitude such that at a defined amplitude, often, for example, ± 0.2 mm, the free path between the upper and the lower grating of the membrane cage is used up. If the amplitudes are less than ± 0.2 mm, as in the case of the said high-frequency, low-amplitude acoustic vibrations, the membrane ideally moves so that no pressure is generated in the chamber. As a result, no force is transmitted and there is no damping, either. The vibrations are isolated from the undercarriage. The present invention, however, is by no means limited to the described decoupling device. For example, the use of other known membranes is also conceivable.

It has been found advantageous during the operation of the bearing to set the passage opening variably as a function of at least one control input provided by the bearing, particularly by means of a control system provided for this purpose. A control input suitable in principle is the frequency of any harmonic excitation.

It has been found advantageous, however, to select as the control input the dominant shaft order, namely for four-cylinder in-line engines the second shaft order. In this manner, it is possible to reduce markedly the vehicle hum which is due essentially to the dominant shaft order. In principle, however, other shaft orders that have a disturbing effect on vehicle acoustics can also

be selected. Thus, it can occur, for example, that at fixed frequencies parts of the vehicle enter into resonance so that it can also be advantageous to set the quenching frequency of the arrangement to these frequencies.

In a preferred embodiment of the invention, the passage opening is formed by a peripherally extending conical surface and, in correspondence with this conical surface, a lowering plate with an adjustable height and disposed in the working chamber. This configuration requires only a minor fabrication expense. In this case, the outer edge of the lowering plate is advantageously bent away from the decoupling device thus forming the wall of a short channel.

The peripherally extending conical surface is advantageously fitted to a ring provided on the dividing wall, because with such an arrangement the damping channel can be integrated into the dividing wall, which reduces the fabrication cost.

For simplicity, the lowering plate is borne by a shifting rod disposed essentially centrally in the bearing and capable of axial movement. Said rod is guided though corresponding central openings from below and penetrates through the compensation chamber all the way into the working chamber. This, too, is a relatively simple construction measure with the aid of which the variable setting of the cross-section of the opening can be achieved more simply.

Advantageously, there is provided a device for the axial displacement of the shifting rod. This device can be, for example, an electric stepping motor.

When active control of the passage opening is intended, the electric motor is operated by means of a control system.

It is also advantageous to provide the lowering plate with an additional passage opening. By this measure, the damping in the low-frequency range is reduced, and the quenching effect is enhanced.

The present invention, however, is not limited to the described configuration. Other designs for realizing a variably adjustable passage opening are conceivable, for example the use of an iris diaphragm, rotary disk valve, blind or throttle valve.

In another advantageous embodiment of the invention, there is provided an idling mode.

According to the invention, the idling mode is obtained during idling by reducing the passage opening to the smallest opening cross-section. Moreover, the decoupling device has a membrane with a free play which is limited during vehicle operation, said free play being released in the idling mode. In this position, the liquid column can vibrate against the expanding spring without being

restricted by the free play. The quenching effect is adjusted to the idling speed. In this embodiment, the assembly bearing of the invention combines in itself all advantages of an idle bearing with those of an actively controllable engine bearing.

The idling mode can be realized simply by providing the shifting rod with an actuation element whereby, when the lowering plate is lowered to attain the smallest opening cross-section, the lower, membrane free play-limiting wall of the membrane cage is entrained downward, for example against the force of a spring, for example a disc spring.

When the lowering plate for reducing damping in the low-frequency range is provided with an additional passage opening, then, in the event of an impact , said lowering plate can during idling move against the conical surface acting as a stop, without adversely affecting the dynamic stiffness. This simplifies the control of the adjusting motor for the lowering plate.

The assembly bearing of the invention provides very good decoupling in the selected, for example dominant, shaft order over the entire rotational speed range.

Moreover, as described hereinabove, with the assembly bearing of the invention, it is possible to achieve effective idling decoupling. Fabrication advantages arise from the fact that the design of the assembly bearing of the invention is very simple, that only low adjustment energy is needed and that no additional mounting space is needed. The assembly bearing of the invention is particularly well suited for all assemblies with pronounced dominant excitation, for example for four-cylinder in-line engines, especially Diesel engines.

Brief Description of the Drawings

In the following, the invention is explained in greater detail be reference to drawings in which:

Figure 1 is a schematic representation of a vertical section through an assembly bearing of the invention in a preferred embodiment;

Figures 2 a,b show a vertical section through an assembly bearing of the invention in the idling mode;

Figure 3 is a schematic representation of a top view of a rotary disk valve for realizing the variably adjustable passage opening;

Figure 4 is a schematic representation of a side view of a blind for realizing the variably adjustable passage opening;

Figure 5 is a schematic representation of a side view of a throttle valve for realizing the variably adjustable passage opening;

Figure 6 shows the qualitative course of the bearing stiffness as a function of frequency for an assembly bearing of the invention with hydraulic damping.

Performance of the Invention

Figure 1 shows a vertical section through a hydraulically damped engine bearing 1 provided with a working chamber 10 and a compensation chamber 20 which is filled with a common hydraulic fluid. Working chamber 10 is limited by a wall 30 shaped as a truncated cone and made of an elastic material and known as the bearing spring. Compensation chamber 20 is limited at the bottom by a cup-shaped wall 40, also made of an elastic material, for example of an air bellows capable of taking up volume without creating pressure. Peripheral wall 30 accomodates bearing plate 32 which faces the engine and which is provided with a protruding screw bolt 34 for fastening to the engine. Between working chamber 10 and compensation chamber 20 is disposed a dividing wall 50 in which is provided a membrane cage 52 containing a membrane 54. In dividing wall 50 is also provided a damping channel 60 which hydraulically interconnects the two liquid-filled chambers 10 and 20. The lower dividing wall 40 of compensation chamber 20 is surrounded by a housing 22 on which is provided a vertically protruding screw bolt 24 for fixing the assembly bearing on the side of the vehicle body.

In the embodiment shown, membrane cage 52 comprises an upper cover part 52a and a lower bottom part 52b. Membrane 54 is disposed in membrane cage 52 so as to be movable in the axial direction. Membrane cage 52 is provided with bars disposed at a distance from one another, between which breaches are provided in the upper cover part 52a and the lower bottom part 52b. The breaches make it possible for the fluid to act on the membrane 54. Membrane 54 is made of an elastic material in a manner which in itself is known.

Moreover, one can see in working chamber 10 an additional passage opening 14 formed by the lowering plate 11 and a corresponding peripherally extending conical surface 13. Lowering plate 11 is borne by an axially movable shifting rod 15. In the embodiment shown, without limiting general applicability, shifting rod 15 can be displaced in the axial direction between an opening and a closing position by means of an electric motor.

During idling, passage opening 14 is closed, and the lowering plate is in the lower, closing position. In this case, the surrounding conical surface 13 forms a stop for the edge of lowering plate 11 that is bent away from decoupling device 54. When the vehicle is in operation, the lowering plate is continuously displaced upward by means of motor 16 in accordance with a pre-specified frequency variation. In this manner, the cross-section of passage opening 14 is continuously increased. Passage opening 14 thus acts as an additional quencher, the quenching point being controlled from outside in accordance with the specified frequency variation. This is reflected in a lowering of the dynamic stiffness of bearing 1 which follows the relevant frequency. The drawing also shows opening 18 in lowering plate 11 which serves to reduce the damping in the low-frequency range.

Figures 2a and 2b represent a diagrammatic sketch of the functioning of the idling mode for assembly bearing 1 of Figure 1. For greater clarity, the bearing components that are not relevant for the operation in the idling mode are not provided with reference numerals. Figure 2a shows assembly bearing 1 of the invention during vehicle operation with passage opening 14 open.

Figure 2b illustrates the functioning of the idling mode. It can be seen from Figure 2b that the lower dividing wall 52b of membrane cage 52 is connected with shifting rod 15 in a manner such that when passage opening 14 is closed by a downward movement of shifting rod 15 and the lowering plate 11, the bottom of membrane cage 52 is also displaced downward. In the embodiment shown, this takes place against the force of a disc spring 19. Lowering plate 11 is displaced downward until its bent-out edge comes to rest on conical surface 13, namely passage opening 14 is closed. By the downward movement of bottom 52b of membrane cage 52, free play is released. Assembly bearing 1 is now in the idling mode.

Figures 3 to 5 exemplify additional design elements for realizing another variably adjustable passage opening according to the invention. Figure 3 shows a diagrammatic sketch of the functioning of a rotary disk valve 11.1, Figure 4 shows that of a blind and Figure 5 that of a throttle valve, in each case with passage openings 14. Because these are only diagrammatic sketches, the other parts of the assembly bearing are not shown.

Figure 3 [sic - Figure 6 seems to be meant - Translator] shows qualitatively the dynamic stiffness of an assembly bearing of the invention against the frequency for various opening cross-sections of the additional opening passage, realized, for example, via different positions of the lowering plate. With increasing opening cross-section, the damping curve is displaced toward higher frequencies. It can also be seen that because of the quenching effect, the dynamic stiffness is reduced below the bearing spring rate. This effect is the more pronounced, the higher the frequency, because for large opening cross-sections the attenuation of the quenching resonance decreases. The reduction can be achieved over a broad frequency range that is significant for

motor vehicle acoustics. The curves shown refer to low amplitudes despite the efficacy of the decoupling device. For this reason, the effect of the damping channel cannot be seen in Figure 3 [sic - Translator].

CLAIMS

1. Assembly bearing with hydraulic damping, particularly for supporting engines and/or gearboxes in motor vehicles, with a working chamber (10) and a compensation chamber (20) each having partially elastically deformable walls (30, 40) and which are separated from one another by a dividing wall (50), but are interconnected through a damping channel (60) through which a liquid is guided, and with an additional passage opening (14) which can be variably adjusted from outside, characterized in that the dividing wall (50) comprises a decoupling device for isolating high-frequency, low-amplitude vibrations and that the additional passage opening (14) is disposed upstream or downstream of the decoupling device.

2. Assembly bearing according to Claim 1, characterized in that the passage opening (14) is disposed upstream of the decoupling device.

3. Assembly bearing according to Claim 1 or 2, characterized in that the decoupling device comprises a membrane (54).

4. Assembly bearing according to one of Claims 1 to 3, characterized in that during the operation of the assembly the passage opening (14) is variably adjustable depending on at least one control input provided by the assembly.

5. Assembly bearing according to Claim 4, characterized in that there is provided a control system for adjusting the passage opening (14).

6. Assembly bearing according to Claim 4 or 5, characterized in that the dominant shaft order is selected as the control input.

7. Assembly bearing according to one of Claims 4 to 6, characterized in that the second shaft order is selected as the control input.

8. Assembly bearing according to one of Claims 1 to 7, characterized in that the passage opening (14) is formed by a peripherally extending conical surface (13) disposed in the working chamber (10) and by a lowering plate (11) of adjustable height and disposed in the working chamber (10) in correspondence with this conical surface (13).

9. Assembly bearing according to Claim 8, characterized in that the outer edge of the lowering plate (11) is bent away from the decoupling device.

10. Assembly bearing according to Claim 7 or 8, characterized in that the peripherally extending conical surface (13) is provided on a ring disposed on the dividing wall (50).

11. Assembly bearing according to one of Claims 8 to 10, characterized in that the lowering plate (11) is borne by a shifting rod (15) disposed essentially centrally in bearing (1) and is axially movable, said rod being guided through the corresponding central openings from below, through the decoupling device (20) and through the compensation chamber (20) and extending all the way into the working chamber (10).

12. Assembly bearing according to Claim 11, characterized in that there is provided a device for an axial displacement of the shifting rod (15).

13. Assembly bearing according to Claim 12, characterized in that the device is an electric motor (16).

14. Assembly bearing according to Claim 13, characterized in that the electric motor (16) is operable by means of a control system.

15. Assembly bearing according to one of Claims 8 to 14, characterized in that the lowering plate (11) is provided with an opening (18) for reducing the damping.

16. Assembly bearing according to one of Claims 1 to 15, characterized in that there is provided an idling mode.

17. Assembly bearing according to Claim 16, characterized in that in the idling mode the passage opening (14) is closed and that the decoupling device is provided with a membrane (54) with limited free play, the free play of the membrane being released in the idling mode.

18. Assembly bearing according to Claim 17, characterized in that to release the free play of the membrane the lower limit of said free play can be lowered.

19. Assembly bearing according to Claim 18, characterized in that the shifting rod (15) is provided with an actuation element whereby when the lowering plate (11) is lowered, the lower limit of the free play of the membrane can be moved downward against a spring force.

20. Assembly bearing according to Claim 19, characterized in that the bottom (52b) of the membrane cage (52) can be moved downward by means of the lowering plate (11).

"Anregungsamplitude" = excitation amplitude; "Trag+Bläh" = bearing spring and expanding spring; "Leerlauffrequenz" = idling frequency; "Adaptive Tilgerfrequenz, einstellbar auf die störende Frequenzen der Anregung" = adaptive quenching frequency, adjustable to the disturbing frequencies of the excitation.